

PATENT COOPERATION TREATY

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REC'D 30 AUG 2005

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY



(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------|
| Applicant's or agent's file reference 85/TY00M54/WO | FOR FURTHER ACTION See Form PCT/PEA/416 | |
| International application No. PCT/B2004/003365 | International filing date (day/month/year) 14.10.2004 | Priority date (day/month/year) 24.10.2003 |
| International Patent Classification (IPC) or national classification and IPC H01M8/02, H01M8/04, H01M8/06 | | |
| Applicant TOYOTA JIDOSHA KABUSHIKI KAISHA et al. | | |

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
 - a. ☒ sent to the applicant and to the International Bureau a total of 9 sheets, as follows:
 - ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
 - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
 - b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:
 - ☒ Box No. I Basis of the opinion
 - ☐ Box No. II Priority
 - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - ☐ Box No. IV Lack of unity of invention
 - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - ☐ Box No. VI Certain documents cited
 - ☐ Box No. VII Certain defects in the international application
 - ☐ Box No. VIII Certain observations on the international application

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| Date of submission of the demand 08.07.2005 | Date of completion of this report 29.08.2005 |
| Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465 | Authorized Officer Wiedemann, E Telephone No. +49 89 2399-7542  |

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/IB2004/003365

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4)
 - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

| | |
|----------|--------------------------------------------------|
| 2-14 | as originally filed |
| 1, 1a-1d | received on 08.07.2005 with letter of 08.07.2005 |

Claims, Numbers

| | |
|------|--------------------------------------------------|
| 1-14 | received on 08.07.2005 with letter of 08.07.2005 |
|------|--------------------------------------------------|

Drawings, Sheets

| | |
|---------|---------------------|
| 1/5-5/5 | as originally filed |
|---------|---------------------|

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/IB2004/003365

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | |
|-------------------------------|-------------|------|
| Novelty (N) | Yes: Claims | 1-14 |
| | No: Claims | |
| Inventive step (IS) | Yes: Claims | 1-14 |
| | No: Claims | |
| Industrial applicability (IA) | Yes: Claims | 1-14 |
| | No: Claims | |

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

1. Reference is made to the following documents:

- D1: US 2003/077487 A1 (ROBERTS JOY A ET AL) 24 April 2003 (2003-04-24)
- D2: US-A-5 441 821 (MERRITT ET AL) 15 August 1995 (1995-08-15)
- D3: PATENT ABSTRACTS OF JAPAN vol. 1997, no. 12, 25 December 1997 (1997-12-25) & JP 09 209810 A (FUJI HEAVY IND LTD), 12 August 1997 (1997-08-12)
- D4: US-A-3 748 180 (CLAUSI J,US ET AL) 24 July 1973 (1973-07-24)
- D5: EP-A-1 223 631 (GENERAL MOTORS CORPORATION) 17 July 2002 (2002-07-17)

2. Amendments

The amendments filed with the letter dated 08.07.2005 are considered to fulfill the requirements of Article 34 (2) PCT.

The basis for new dependent claim 14 can be found in the description (paragraphs 0028-0031 in connection with fig. 1).

The relevant state of the art was further added to the description.

3. Novelty and Inventive Step

The document D1 is regarded as being the closest prior art to the subject-matter of claim 1.

The subject-matter of claim 1 differs from the disclosure of D1 in that the document does not provide a solution to determine a possible malfunction of a hydrogen discharge valve.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention is considered to provide an abnormality detecting device for detecting an abnormality in a hydrogen discharge valve regardless of an operation state of the fuel cell.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

No prior art document discloses an abnormality detecting device for a hydrogen discharge valve. Furthermore, the detection of the functioning of the hydrogen discharge valve allows control of the functioning of the fuel cell without interfering with the gas circulation.

Claims 2-14 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

4. Industrial Applicability

The subject-matter of the present application is industrially applicable in field of fuel cell control.

TFN040090-PCT

ABNORMALITY DETECTING DEVICE OF FUEL CELL SYSTEM

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2003-364524 filed on October 24, 2003 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates to an abnormality detecting device for detecting an abnormality in a hydrogen discharge valve provided in a fuel cell system.

2. Description of the Related Art

[0003] In a fuel cell system in which electric power is generated by supplying fuel gas and oxidizing gas to a fuel cell stack constituted by stacking plural cells in series, there is a known structure in which unreacted hydrogen gas is reused for a cell reaction by making hydrogen off-gas (anode off-gas) discharged from an anode gas channel flow back to an anode. A hydrogen discharge valve for discharging part of the hydrogen off-gas is provided in a hydrogen off-gas circulation passage. By regularly opening the hydrogen discharge valve when a concentration of ingredients other than hydrogen contained in hydrogen off-gas becomes high, a concentration of hydrogen to be supplied to the anode is maintained appropriately. However, if an abnormality occurs in the hydrogen discharge valve and opening/closing operation of the valve cannot be performed properly, a problem occurs in a cell operation. Accordingly, Japanese Patent Laid-Open Publication No. 2003-92125 discloses a technology for detecting a hydrogen discharge command to a hydrogen discharge valve, and determining whether a failure has occurred in the hydrogen discharge valve based on a target pressure of a fuel supply portion of a fuel cell stack and an actually detected value.

[0004] According to the technology disclosed in this publication, however, the determination as to whether a failure has occurred in the hydrogen discharge valve is made only when the fuel cell is being operated normally. Accordingly, when the fuel cell is in a transition state, for example, when an accelerator pedal is depressed abruptly, an appropriate failure determination cannot be made.

- 1a

Document US 5,441,821 discloses an electric power generation system having a regulated vacuum ejector for recirculating the fluid fuel stream. The system includes a fuel cell stack, a pressurised fuel supply having a pressure control valve for regulating the pressure of the fuel supply, a vacuum ejector
5 interposed between the fuel supply and the stack fuel stream inlet, a pressure transducer interposed between the ejector discharge outlet and the stack fuel stream inlet, and a pressurised oxidant supply with a pressure transducer. The ejector suction inlet is fluidly connected to the fuel stream outlet of the fuel cell stack. The fuel stream pressure transducer transmits a signal to the pressure control
10 valve to adjust the pressure of the fuel supply when the detected pressure of the fuel stream deviates from a predetermined value. The oxidant stream pressure transducer transmits a signal to the pressure control valve to adjust the pressure of the fuel supply when the detected pressure of the oxidant stream changes.

15 Further, document JP 09-209810 discloses a failure detector for intake air control valve mechanism of an engine to easily detect a failure condition of an intake air control valve mechanism without accompanying complexation of construction and control, and to externally display the failure condition rapidly and certainly, by composing a driving means control part and a failure judging part in
20 an ECU, and externally displaying the failure condition of the intake air control valve mechanism on an display. In this detector, an engine operating condition detecting means is arranged which judges whether or not an engine operating condition is in regular condition. Further, a pressure sensor detects pressure in an intake air pass when the intake control valve is opened/closed. When pressure
25 difference in opening/closing periods between the detected pressure is at a predetermined value or more, failure judging means in the ECU judges that the engine operating condition is normal, and when pressure difference is smaller than the predetermined value, it judges that the engine operating condition is normal, and when pressure difference is smaller than the predetermined value, it judges
30 that the engine operating conditions is in failure condition. Displaying means

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externally displays whether or not the engine operating condition is in failure condition on the basis of these judgement.

5 A fuel cell system from an underwater vehicle is further disclosed in document US 3,748,180. This fuel cell system has at least one fuel cell module for supplying electrical power for said vehicle. A first tank containing hydrogen is connected to one reactant chamber of a fuel cell module and a second tank containing oxygen is connected to another reactant chamber of the fuel cell module. The hydrogen product water output from the hydrogen reactant chamber is
10 condensed and separated and the water produced is stored in the first tank containing hydrogen. The fuel cell module is placed in a containment vessel which is pressurised with nitrogen. A catalytic reactor is provided in the containment vessel to form water in the event that there are simultaneous leaks in both the hydrogen and oxygen high pressure supply lines. A pressure transducer is also
15 provided in the containment vessel for shutting down the system if there is a high pressure leak in either the hydrogen or oxygen line.

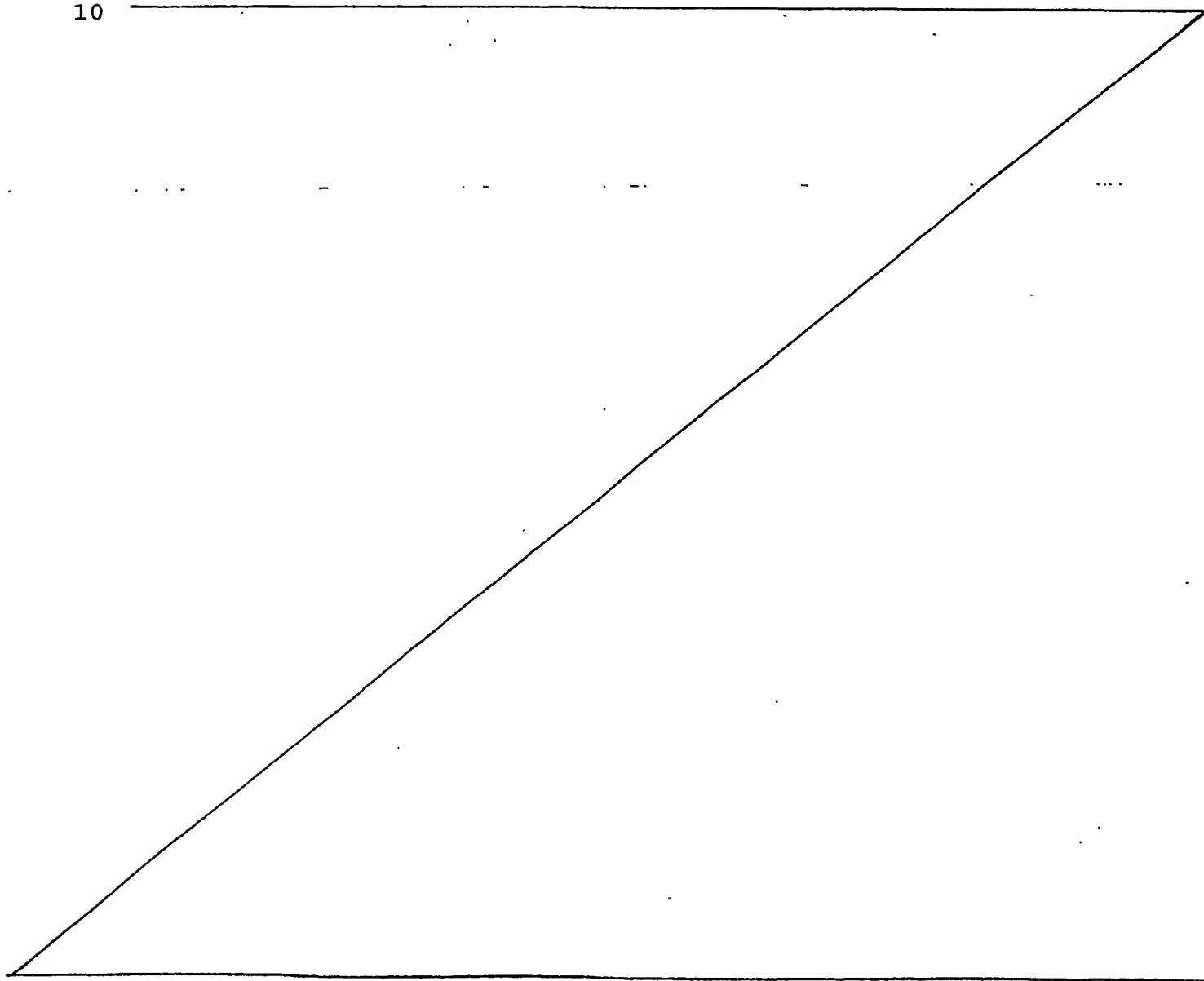
Further, document EP 1 223 631 A2 discloses a method and apparatus for detecting leakage current in the coolant of a fuel cell stack between said stack and
20 the grounded stack chassis, using a voltmeter to measure the voltage across the coolant. If the coolant voltage is at or below a predetermined level, an excessive level of conductivity in the coolant exists, and the presence of leakage current is reported.

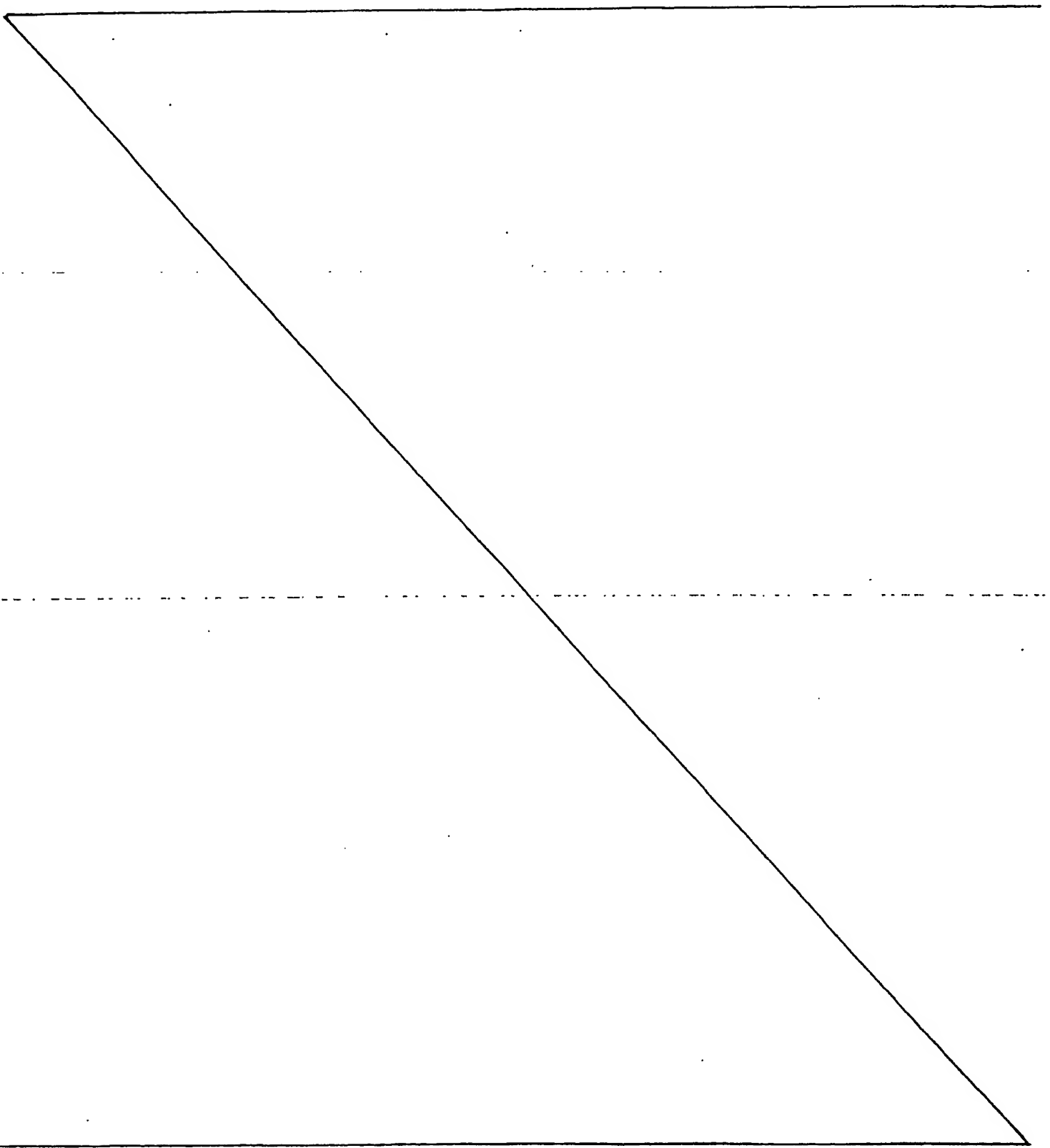
25 Further, document US 2003/077487 A1 discloses methods for improving the cold starting capability of an electrochemical fuel cell wherein temperature dependent methods can be used to improve the cold start capability of fuel cell electric power generation systems. A method of ceasing operation of an electric power generation system improves the cold start capability and freeze tolerance of
30 a fuel cell stack by reducing the amount of water remaining within the passages of

- 1c

the stack. The method involves purging one or more of the fuel cell stack oxidant and fuel passages at shutdown prior to allowing the fuel cell stack to drop to temperatures below the freezing point of water. Preferably purging at shutdown is conducted at a temperature below the stack operating temperature. Another method, used at start-up, involves directing a coolant fluid stream to the fuel cell stack only after a predetermined temperature above the freezing temperature of water is exceeded. Preferably, after freezing the fuel cell stack is heated to a temperature above its normal operating temperature before the operation is commenced.

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[0005] It is therefore an object of the invention to solve the above-mentioned problem,
and provide an abnormality detecting device for detecting an abnormality in a hydrogen

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fair copy**(amended) Claims**

1. An abnormality detecting device of a fuel cell system, comprising:
a hydrogen off-gas circulation passage for making hydrogen off-gas discharged from a fuel cell flow back to an anode of the fuel cell;
a discharge passage for discharging part of the hydrogen off-gas, which is circulated through the hydrogen off-gas circulation passage, from the hydrogen off-gas circulation passage;
a hydrogen discharge valve provided in the discharge passage; and
abnormality determining means for determining whether an abnormality has occurred in opening/closing of the hydrogen discharge valve, characterized by further comprising:
gas state quantity detecting means for detecting a gas state quantity of the hydrogen off-gas, the gas state quantity detecting means being provided in the discharge passage at a position downstream from the hydrogen discharge valve, wherein the abnormality determining means determines whether an abnormality has occurred in opening/closing of the hydrogen discharge valve based on the gas state quantity of the hydrogen off-gas.
2. The abnormality detecting device of a fuel cell system according to claim 1, further comprising:
a mixing chamber for mixing the hydrogen off-gas discharged from the discharge passage with external gas, wherein the gas state quantity detecting means detects the gas state quantity of the hydrogen off-gas which is mixed with the external gas in the mixing chamber.
3. The abnormality detecting device of a fuel cell system according to claim 2, wherein the external gas is part of oxidizing gas to be supplied to a cathode of the fuel cell.

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4. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 3, wherein the hydrogen discharge valve is an electromagnetic valve, and the abnormality determining means determines whether an abnormality has occurred in opening/closing of the hydrogen discharge valve based on the gas state quantity detected by the gas state quantity detecting means so as to deal with a change in an input of an opening/closing control signal to the electromagnetic valve.
5. The abnormality detecting device of a fuel cell system according to claim 4, wherein the abnormality determining means determines whether an abnormality has occurred in opening/closing of the electromagnetic valve based on a change with time in the gas state quantity detected by the gas state quantity detecting means so as to deal with the change in the input of the opening/closing control signal to the electromagnetic valve.
6. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 5, wherein the gas state quantity is a physical quantity related to one of a hydrogen concentration, a flow speed, a pressure, a proportion of each ingredient, a temperature and a dielectric constant of the hydrogen off-gas.
7. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 6, further comprising:
gas state quantity detecting means for detecting the gas state quantity of the hydrogen off-gas, the gas state quantity detecting means being provided in the discharge passage at a position upstream from the hydrogen discharge valve, wherein the abnormality determining means detects an abnormality in opening/closing of the hydrogen discharge valve based on the gas state

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quantity detected by the gas state quantity detecting means provided on each of an upstream side and a downstream side of the hydrogen discharge valve.

8. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 7, further comprising:
gas-liquid separating means for separating the hydrogen off-gas into gas and liquid, wherein the gas state quantity detecting means detects the gas state quantity of the hydrogen off-gas which has been separated into gas and liquid by the gas-liquid separating means.
9. The abnormality detecting device of a fuel cell system according to any one of claim 6 to claim 8, further comprising:
a pressure sensor which is provided in the discharge passage at a position downstream from the hydrogen discharge valve, and which detects a pressure of the hydrogen off-gas.
10. The abnormality detecting device of a fuel cell system according to any one of claim 6 to claim 8, further comprising:
a temperature sensor which is provided in the discharge passage at a position downstream from the hydrogen discharge valve, and which detects a temperature of the hydrogen off-gas.
11. The abnormality detecting device of a fuel cell system according to any one of claim 6 to claim 8, further comprising:
paired electrodes which are provided in the mixing chamber and which are opposed to each other in order to detect a dielectric constant of the hydrogen off-gas.
12. The abnormality detecting device of a fuel cell system according to any one of claim 6 to claim 8, further comprising:

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a heat wire resistance which is provided in the mixing chamber and which detects a heat conductivity of the hydrogen off-gas.

13. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 12, further comprising:
means for dealing with a failure when the abnormality determining means detects an abnormality in opening/closing of the hydrogen discharge valve.
14. The abnormality detecting device of a fuel cell system according to any one of claim 1 to claim 13, wherein the gas state quantity detecting means being provided in the discharge passage at a position outside the hydrogen off-gas circulation passage.